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ABSTRACT

The goals of the project were: (1) to develop elementary mathematics instructional materials which incorporate the use of hand calculators; (2) to develop an appropriate teacher training program; (3) to improve students' basic mathematics skills; (4) to improve students' understanding of mathematics concepts and processes; (5) to improve students' attitudes toward mathematics; and (6) to increase teachers' understanding of hand calculators and their use in the instructional program. In the two years of the project, materials were developed and field tested in 90 classrooms, grades 4-6. Two of the nine performance objectives were achieved: the training of pilot and field test teachers. None of the seven performance objectives for students were achieved. However, the criterion level of performance was reached on the tests of module achievement in two modules. Students exhibited gains on the computations subtest of the Comprehensive Tests of Basic Skills, but not on the arithmetic concepts and applications subtests. At the end of the project, more than 50 percent of the parents were favorable to the use of calculators in math classrooms. The Columbus Public Schools will continue to make calculators and the instructional materials available to teachers. (Author/BW)

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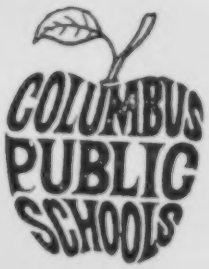
Improving Mathematic Achievement of Elementary Students Through the Use of Electronic Hand Calculators



January, 1980

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Columbus, Ohio Public Schools
Department of Management Planning and Information

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Improving Mathematics Achievement of Elementary Students Through the Use of Electronic Hand Calculators

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Section A

Summary

Improving Mathematic Achievement of Elementary Students Through the Use of Electronic Hand Calculators

Needs Assessment:

Data based on the Columbus Public Schools testing program, research projects, and needs assessment process confirm the need to improve mathematical basic skills at the local level. Inputs from teachers, senior high school students, and recent graduates indicate a need for improved teacher training in mathematics instructions and an improvement in student attitudes towards mathematics in general.

An immediate need exists to improve mathematical skills among elementary and secondary pupils. Mathematics educators and elementary classroom teachers have expressed support for the use of calculators in the classroom as a means of giving students a different approach to learning mathematics. Classroom teachers have strongly supported the viewpoint that calculators can be used more effectively with children in grades 4 through 12 than with children in lower grades.

A review of the literature indicated that the need also exists to utilize modern technology in the classroom to enhance the instructional process and to prepare students to meet the burgeoning demands of technological programs.

The availability of calculators in the classroom together with instructional packages would present a fresh and viable approach to improving skills in mathematics. It is hypothesized that not only would such an approach improve student mastery of basic mathematics skills, the use of calculators would inspire student motivation and improve student attitudes toward the study of mathematics in general.

Project Goals:

The goals of the project are:

1. To develop mathematics instructional materials which incorporate the use of hand calculators at the elementary level.

2. To develop a teacher training program for improving teacher understanding of mathematics content and teaching methods related to the instructional use of hand calculators.

3. Students will demonstrate improved ability in the basic mathematics skills.

4. Students will demonstrate improved understanding of the mathematics concepts and processes appropriate for their grade levels.

5. Students will demonstrate improved attitudes toward learning and using mathematics.

6. Teachers will demonstrate an understanding of hand calculators and their use in the instructional program, and of the mathematics content introduced into the elementary mathematics curriculum in conjunction with the use of hand calculators.

Program Description:

The major tasks of the first year of the project were: (a) to develop the mathematics instructional materials which incorporate the use of hand calculators in grades four through six; (b) to develop a teacher training program for improving teacher understanding of mathematics content and teaching methods related to the instructional use of hand calculators; (c) to evaluate the effectiveness of the teacher training program with a pilot group of teachers; (d) to pilot test the mathematical instructional materials in the classrooms of teachers participating in the pilot testing of the teacher training program; (e) to revise the instructional materials based on the results of the pilot testing; (f) to revise the teacher training program based on the results of the pilot testing; (g) to revise the teacher training program based on the results of the evaluation; and (g) to provide inservice for field test teachers.

The products of the first year of the project included the following: (a) an up-to-date annotated list of literature, research, and materials related to the development of mathematics skills and the use of calculators with elementary school children; (b) a tested teacher training program that includes instructions in how to use calculators in the classroom, new problem solving and instructional opportunities that exist as a result of the availability of calculators, and pretest and posttest assessment of teacher understandings and skills relative to the use of calculators in the mathematics curriculum; (c) classroom tested student instruction packages for grades 4, 5 and 6 consisting of problems and activities that will improve student mathematics skills; (d) an evaluation report on the teacher training program pilot testing and (e) an evaluation report on the instructional materials pilot testing.

The second year of the project was devoted to field testing of the student instructional packages developed during the first year, observing classrooms, and making the final revisions to the student instructional packages.

For the field test, 90 classes of fourth, fifth and sixth grade teachers who agreed to participate in the field test were randomly assigned to the two treatment groups and the control group. The first treatment group used calculators and the student instructional packages under the supervision of a trained teacher. The second treatment group had access to calculators but not to the instructional packages. The control group received the regular mathematics program. Students in all three groups were pretested and posttested using appropriate measures of achievement in mathematics and attitude toward mathematics. The posttest scores of the means of classes in all three groups have been compared by using analysis of covariance with the mean pretest scores of classes as covariates. The analysis compared posttest class means across grade levels and tested for significant interactions between grade level and treatment.

The teachers chosen for the calculator and materials group received twenty hours of instruction on the use of calculators and materials during October and November, 1978. Teachers who received only calculators received instruction on how to operate and maintain calculators in the classroom. All teachers participating in the study received two hours of inservice on testing and observation procedures that were to be employed in the study.

After the field test, input from teachers, test scores, and observation data, the project made final edit changes for printing and dissemination.

Findings:

Two of the nine performance objectives of the two year project were achieved. The two performance objectives which were achieved related to the training of pilot and field test teachers to use calculators and materials in classroom instruction. In addition, teachers rated the training workshops highly in terms of value to them in teaching mathematics.

None of the seven performance objectives for students were achieved. However, the criterion level of performance was reached on the tests of module achievement in two modules - Basic Facts and Properties. With the use of a calculator, students were able to perform at the criterion level on the Decimal Computations Test, but they could not reach the criterion level using paper and pencil.

Students exhibited approximately a three month gain in grade equivalent scores on the computations subtest of the Comprehensive Test of Basic Skills when they were permitted to use calculators rather than just paper and pencil. However, calculators made little difference in the grade equivalent of average scores on the arithmetic concepts and applications subtests.

At the end of the project, more than fifty percent of each group of parents were favorable to the use of calculators in math classrooms. Sixty-one percent of the calculator-material group of parents were favorable to the use of calculators in the math class. Several parents expressed appreciation of the opportunity for their children to be exposed to calculators in a meaningful situation. The fact that one group of children used specially designed instructional materials for calculators did not seem to effect the feeling of parents.

The Columbus Public Schools will continue to make calculators and the instructional materials developed during this project available to teachers. However, due to financial limitations, the system will be unable to support the training of teachers for the calculator program.

It is recommended that the mathematics achievement of students who participated in the study be monitored to determine any long range effects of the use of calculators. A follow-up study of any teachers who participated in the study and who continue to use calculators in their classrooms should be conducted to determine any long term effects of the use of calculators upon approaches to the teaching of mathematics.

Section B

Needs Assessment

B. Needs Assessment

In January, 1977, a Position Paper on Basic Mathematical Skills was presented by the National Council of Supervisors of Mathematics emphasizing the immediate need for the improvement of mathematical skills among elementary and secondary students. These same sentiments were emphasized in 1975 by two reports published by the National Assessment of Educational Progress. These reports, Math Fundamentals and Consumer Math, verify that a substantial segment of youth cannot perform adequately with fundamental mathematical concepts and skills. Of particular note is the difficulty children have in handling basic skills concerning fractions, approximating measurement, and problem solving.

The available evidence suggests that an incipient problem exists at the state and national level in meeting acceptable performance levels in mathematical skills. These studies infer that significant portions of society will not have adequate command of mathematics for comfortable resolution of problems in their personal lives, for knowledgeable participation in a democratic society, or for providing the stimulating and sustaining atmosphere necessary for creative leadership in industry, science and technology.

These problems identified by the National Assessment of Educational Progress have also been confirmed at the local level. The problems identified at the state and national levels exist in the Columbus Public Schools. The need is specific to intermediate grade levels - grades 4, 5 and 6. In terms of solution strategies, teachers and math educators support the view that hand calculators in the elementary classroom can improve student achievement in basic math skills.

The learner needs specific to the Columbus Public Schools have been identified from research projects and from a needs assessment process which includes data gathered from an annual city wide testing program, from a Student Opinion Survey, from a Graduate Follow-up Study, and from classroom teacher surveys.

As part of the needs assessment process the Columbus Public Schools has conducted an annual city wide testing program. Each year all students in grades 4, 5 and 6 complete the Comprehensive Test of Basic Skills, published by the California Test Bureau, a division of the McGraw-Hill Book Co. From 1973 until 1976, over 140,000 students in Columbus Public Schools completed the arithmetic battery of the Comprehensive Tests of Basic Skills. This number includes almost 30,000 pupils each from grades 4, 5 and 6.

The results from these four years of standardized testing provide evidence of definitive weaknesses in student proficiency in mathematics skills. Table 1 demonstrates that although students in these grade levels have scored near or above national norms on the computations and concepts subtests, these students have consistently evidenced poorer achievement levels on the applications subtest. On the average, across the four year period 13.6 percent fewer students score at or above grade level on the applications subtest than on the computation subtest.

A further analysis of the achievement test data indicates that as students progress from grade to grade, scores on mathematics subtests are more likely to decline. For example, in 1973, 57.1 percent of the fourth graders scored at or above grade level on the computations subtest. In 1974, as fifth graders, 47.1 percent scored at or above grade level on the computations subtest, and as sixth graders only 45.2 percent scored at or above grade level. This decline in achievement scores is reflected not only in computations but also in applications. Table 2 summarizes this data.

Further analysis of the 1975 and 1976 standardized achievement tests reveals that student deficiencies in mathematics applications are not confined to specific schools or groups of students. Low scores were pervasive across the total school system. For example, in comparing fourth and fifth grade student scores on the computations subtest with scores on the applications subtest, it was found that out of 123 schools, over 90% of the schools registered lower student scores on applications, than on computations. At the sixth grade level, over 83% of the schools registered lower student scores on the applications subtest than on the computations subtest.

In summary, test data gathered since 1973 show strong evidence that fourth, fifth and sixth grade students in the Columbus Public Schools score significantly lower in arithmetic applications than in computation skills or knowledge of mathematical concepts as measured by a standardized test. Further, the data show evidence that student mathematics skills are more likely to decline as students progress from fourth to sixth grade.

A further part of the needs assessment process of the Columbus Public Schools is an annual Graduate Follow-up Survey. Since 1969 over 5,000 survey questionnaires have been completed by graduates of the Columbus Public Schools. When asked to evaluate how effective their high school education had been as a preparation for adult life, over 50% of the 1972 and 1973 graduates rated their education in mathematics skills as "fair" after being out of school for three years. Thirteen percent rated their education in mathematics skills as "poor". Open-ended comments by graduates indicated that many former students were not well motivated to improve mathematics skills while in school.

Table 1

Percent of Fourth, Fifth and Sixth Grade Students Scoring at or Above Grade Level on the Arithmetic Computations, Concepts and Applications Subtest of the Comprehensive Test of Basic Skills in the Columbus Schools

Grade 4

Test Date	Computations	Concepts	Applications
April 1973	57.1	49.4	40.3
April 1974	56.0	49.5	38.3
April 1975	60.6	55.1	41.0
April 1976	62.2	54.8	40.8

Grade 5

Test Date	Computations	Concepts	Applications
April 1973	46.6	45.0	38.9
April 1974	47.1	43.9	36.5
April 1975	52.1	45.5	38.8
April 1976	56.2	56.6	39.5

Grade 6

Test Date	Computations	Concepts	Applications
April 1973	42.8	41.0	34.0
April 1974	36.2	39.6	30.7
April 1975	45.2	47.8	34.0
April 1976	49.3	48.0	35.6

Table 2

Percent of Students Scoring at or Above Grade Level on the Arithmetic Computations, Concepts, and Applications Subtests of the Comprehensive Tests of Basic Skills by Grade Level and Test Date

Computations

	4th Grade	(Year)	5th Grade	(Year)	6th Grade	(Year)
Class of 1973	57.1	(1973)	47.1	(1974)	45.2	(1975)
Class of 1974	56.0	(1974)	52.1	(1975)	49.3	(1976)
Class of 1975	60.6	(1975)	56.2	(1976)	-	

Concepts

	4th Grade	(Year)	5th Grade	(Year)	6th Grade	(Year)
Class of 1973	49.4	(1973)	43.9	(1974)	47.8	(1975)
Class of 1974	49.5	(1974)	45.6	(1975)	48.0	(1976)
Class of 1975	55.1	(1975)	56.6	(1976)	-	

Applications

	4th Grade	(Year)	5th Grade	(Year)	6th Grade	(Year)
Class of 1973	40.3	(1973)	36.5	(1974)	34.0	(1975)
Class of 1974	38.3	(1974)	38.8	(1975)	35.6	(1976)
Class of 1975	41.0	(1975)	39.5	(1976)	-	

Data gathered from the American College Testing scores for Columbus students further confirms the need for improvement in basic mathematical skills. Each year, approximately 2,000 Columbus seniors take the ACT battery. For the past three years Columbus students have scored below both the national mean and the Ohio mean on the mathematics subtest.

One further piece of evidence collected as part of the needs assessment process is based on the annual Student Opinion Survey which is completed by all students in the senior high school. One question asked of students how satisfied they are with their abilities in math computations and in math applications. Approximately 14,000 tenth, eleventh and twelfth grade students completed the survey. Although 89% indicated they were satisfied with their computations skills, only 60% reported that they were satisfied with their math applications skills. Almost one-fourth, 3,000 students, reported they were dissatisfied with their ability to apply mathematics in solving problems.

The needs assessment process also included teacher input. Elementary classroom teachers were surveyed early in the 1976-77 school year to identify their greatest need for inservice workshops. The overwhelming majority of teachers cited a critical need to improve the instruction of basic mathematics.

In summary, data gathered by the Columbus Public Schools since 1973 from research projects and from the needs assessment process attests to the need for improvement in the teaching of mathematics skills in the early years of the educational program.

A brief review of recent literature has disclosed great support for the use of calculators in math instruction.

The Curriculum Report, Volume 4, October 4, 1974, from the Curriculum Service Center, National Association of Secondary School Principals, states that calculators will drastically change the way computation is taught, and teachers would be well-advised to begin to experiment in the classroom with pocket calculators, focusing on their use as a tool in successful problem-solving.

On October 30, 1975, the Education Daily reported that "both the National Council of Teachers of Mathematics and the National Association of Secondary School Principals are on record as encouraging use of calculators in classrooms."

In October, 1975, Kaufman, Hoag, Papy and Sterling presented a position paper at the Conference on Basic Mathematical Skills and Learning entitled "Basic Mathematical Skills and Learning: The CSMP Viewpoint." One section of that paper is worthy of quotation:

> The hand calculator is one of the most potent educational tools technology has provided. Its potential positive impact on the learning of mathematics, particularly at the elementary school level, is enormous. It will act in a supportive, interactive manner with the growth of children's numerical skills and understanding. It should be as ubiquitous in the classroom as the ruler or the compass.

A survey of elementary teachers in the Columbus Public Schools regarding the role and use of electronic hand calculators in teaching mathematics was conducted during the 1975-1976 school year. A significant number of teachers reported serious reservations about the use of calculators in grades K, 1, 2 and 3. However, a majority of teachers surveyed felt that calculators could be used effectively in grades 4 through 12 to improve student achievement in mathematics.

Mathematics educators and elementary classroom teachers, therefore, have both expressed support for the use of calculators in the classroom. Further, classroom teachers have strongly supported the viewpoint that calculators can be used more effectively with children in grades 4 through 12 than with children in lower grades.

In summary, it has been shown that an immediate need exists to improve mathematical skills among elementary and secondary pupils. Teacher surveys have indicated that the most effective use of calculators in the elementary classroom would be with students in grades 4 through 6.

Data based on the Columbus Public Schools testing programs, research projects, and needs assessment process confirm the need to improve mathematical basic skills at the local level. Inputs from teachers, senior high school students, and recent graduates indicate a need for improved teacher training in mathematics instructions and an improvement in student attitudes towards mathematics in general.

A review of the literature indicated that the need also exists to utilize modern technology in the classroom to enhance the instructional process and to prepare students to meet the burgeoning demands of technological programs.

The availability of calculators in the classroom together with instructional packages would present a fresh and viable approach to improving skills in mathematics. It is hypothesized that not only would such an approach improve student mastery of basic mathematics skills, the use of calculators would inspire student motivation and improve student attitudes toward the study of mathematics in general.

The percent of fourth, fifth, and sixth grade students scoring at or above grade level on the reading vocabulary and reading comprehension subtests of the CTBS for April, 1973 through April, 1976 are summarized in Table 3. For every year, grade level, and test the percent of students scoring at or above grade level on these two subtests are larger than the corresponding percent for the arithmetic applications subtest. This suggests that factors other than reading ability are affecting applications test scores.

The percent of students scoring at or above grade level does not decline as markedly as the mathematics scores do as students progress from grade four through grade six.

The Columbus Public Schools through Project UNITE (1971) and published positions of members of the Board of Education have established that the development of basic skills in reading and mathematics is to be emphasized at all grade levels. Through the accountability publications called the Columbus School Profile, The Columbus School Report, and now, Progress In Education the school system has implicitly established fifty percent at or above grade level as the desired level of performance on standardized tests of achievement.

Table 3

Percent of Fourth, Fifth and Sixth Grade Students Scoring At or Above Grade Level on the Reading Vocabulary and Reading Comprehension Subtests of the Comprehensive Test of Basic Skills in the Columbus Schools

Grade 4

Test Date	Vocabulary	Comprehension
April 1973	43.6	43.4
April 1974	48.4	44.0
April 1975	51.5	47.9
April 1976	54.3	47.0

Grade 5

Test Date	Vocabulary	Comprehension
April 1973	39.5	40.0
April 1974	38.4	41.2
April 1975	44.1	43.4
April 1976	44.5	44.6

Grade 6

Test Date	Vocabulary	Comprehension
April 1973	39.5	39.3
April 1974	40.1	38.5
April 1975	45.1	42.8
April 1976	44.9	41.1

Section C

Project Goals

C. Project Goals

The goals of the project are:

1. To develop mathematics instructional materials which incorporate the use of hand calculators at the elementary level.

2. To develop a teacher training program for improving teacher understanding of mathematics content and teaching methods related to the instructional use of hand calculators.

3. Students will demonstrate improved ability in the basic mathematics skills.

4. Students will demonstrate improved understanding of the mathematics concepts and processes appropriate for their grade levels.

5. Students will demonstrate improved attitudes toward learning and using mathematics.

6. Teachers will demonstrate an understanding of hand calculators and their use in the instructional program, and of the mathematics content introduced into the elementary mathematics curriculum in conjunction with the use of hand calculators.

Section D

Program Description

D. Program Description

Test data gathered by the Columbus Public School District since 1973 shows strong evidence that fourth, fifth and sixth grade students score significantly lower in their ability to solve applications problems than in computational skills or knowledge of mathematical concepts as measured by the comprehensive tests of basic skills.

The hand calculator should allow students more time to read and analyze application problems since not as much time needs to be spent in calculating answers. It was felt that if more application problems were presented to students, their skills involving applications would improve. Throughout the project, the students were expected to solve application problems from their textbooks and from the special unit designed for the hand calculator.

If calculators were to be used in grades four, five and six, several questions had to be considered: Can elementary students work with decimal numbers? Will students believe calculator answers when in fact errors might have been made? Will students understand the decimal point placement in calculator answers? Will students be able to round decimal numbers with many digits to more workable numbers? Will students understand the importance of entering numbers into the calculator in the correct order? Will students become dependent upon the calculator as they work on various concepts and mathematical processes?

The previous questions were the major concerns of the project staff throughout the developmental process. A unit was written for each concern. It is felt that the units: Basic Facts; Place Value; Decimal Computation; Properties; Rounding and Estimation thoroughly prepare the students for activities in solving problems in the unit titled Applications.

The major tasks of the first year of the project were: (a) to develop the mathematics instructional materials which incorporate the use of hand calculators in grades four through six; (b) to develop a teacher training program for improving teacher understanding of mathematics content and teaching methods related to the instructional use of hand calculators; (c) to evaluate the effectiveness of the teacher training program with a pilot group of teachers; (d) to pilot test the mathematical instructional materials in the classrooms of teachers participating in the pilot testing of the teacher training program; (e) to revise the instructional materials based on the results of the pilot testing; (f) to revise the teacher training program based on the results of the pilot testing; (g) to revise the teacher training program based on the results of the evaluation; and (g) to provide inservice for field test teachers.

The products of the first year of the project included the following: (a) an up-to-date annotated list of literature, research, and materials related to the development of mathematics skills and the use of calculators with elementary school children; (b) a tested teacher training program that includes instructions in how to use calculators in the classroon, new problem solving and instructional opportunities that exist as a result of the availability of calculators, and pretest and posttest assessment of teacher understandings and skills relative to the use of calculators in the mathematics curriculum; (c) classroom tested student instruction packages for grades 4, 5 and 6 consisting of problems and activities that will improve student mathematics skills; (d) an evaluation report on the teacher training program pilot testing and (e) an evaluation report on the instructional materials pilot testing.

The second year of the project was devoted to field testing of the student instructional packages developed during the first year, observing classrooms, and making the final revisions to the student instructional packages. The project coordinator, in consultation with the project director, prepared a schedule of assignments for himself and the two teachers assigned to the project. The schedule was designed to insure completion of activities on a timely basis with an equitable distribution of the workload among project staff.

For the field test, 90 classes of fourth, fifth and sixth grade teachers who agreed to participate in the field test were randomly assigned to the two treatment groups and the control group. The first treatment group used calculators and the student instructional packages under the supervision of a trained teacher. The second treatment group had access to calculators but not to the instructional packages. The control group received the regular mathematics program. Students in all three groups were pretested and posttested using appropriate measures of achievement in mathematics and attitude toward mathematics. The posttest scores of the means of classes in all three groups have been compared by using analysis of covariance with the mean pretest scores of classes as covariates. The analysis compared posttest class means across grade levels and tested for significant interactions between grade level and treatment.

The teachers chosen for the calculator and materials group received twenty hours of instruction on the use of calculators and materials during October and November, 1978. Teachers who received only calculators received instruction on how to operate and maintain calculators in the classroom. All teachers participating in the study received two hours of inservice on testing and observation procedures that were to be employed in the study.

During the field test, project staff observed classrooms using the student instructional packages. The staff systematically recorded any problems with the instructional materials and rated any corrections which needed to be made to the materials. They have made minor changes and editorial corrections to the instructional materials based upon the observations and the results of teacher-administered tests of student instructional module achievement. The changes have been reviewed by a panel of experts. The final edited copy of each instructional module has been prepared for dissemination.

The Columbus Calculator Project was funded entirely through ESEA Title IV-C funds.

Total federal support under ESEA Title IV-C	$241,655.37
Total federal support other than ESEA Title IV-C	-0-
Total non-federal support	-0-
Total project cost	$241,655.37

Section E

Project Outcomes

E. Project Outcomes

The results of the two year project will be reported by student and teacher performance objectives. Results from each year of the study will be included with each set of performance objectives. After each group of performance objectives, outcomes of the related facilitating objectives will be discussed.

A description of additional evaluation activities for both years of the project will be presented at the end of this section.

Student Performance Objectives

First Year: 1977-1978

OBJECTIVE: After receiving 8 weeks of instruction involving a sample of the materials developed for the student instruction package from a trained teacher, 80 percent of the students in the pilot classes will demonstrate the ability to correctly solve 75 percent of selected problems relating to the objectives of the instruction as measured by a locally constructed test administered by the students' classroom teachers on or before May 31, 1978.

The project staff developed instructional modules with specified objectives for the seven areas of mathematics: Basic Facts, Place Value, Rounding, Estimation, Decimal Computations, Properties, and Applications. With the exception of the Properties and Applications modules, the modules were designed to be used in grades four, five and six. However, slightly different Properties and Application modules were developed for grade four than for grades five and six. The evaluator in consultation with the project staff developed tests of module achievement designed to measure the specified objectives of each module.

Since the time available for pilot testing materials was limited, not every teacher piloted every module. The modules to be piloted by each teacher were assigned subject to the following conditions: (1) if possible, every module should be piloted at all three grade levels, and (2) no module should be pilot tested in a classroom that had not piloted the appropriate prerequisite modules.

Based on these conditions the scheme for pilot testing modules depicted in Figure 1 was developed.

	Teachers								
	Grade 4			Grade 5		Grade 6			
Module	A	B	C	D	E	F	G	H	I
Basic Facts						X	X	X	
Place Value	X		X	X	X	X	X		
Rounding		X			X			X	X
Estimation		X			X			X	
Decimal Computations	X			X			X		
Properties			X			X			X
Applications		X	X	X					X

Figure 1

A Representation of the Design to Pilot Test Student Instructional Modules

Teachers for the pilot testing were selected from among volunteers according to the following criteria: (1) one teacher will be from the Catholic School System and one teacher will be from Torah Academy; (2) all three grade levels must be represented; and (3) the schools participating should be drawn equally from areas of high, medium, and low incidence of aid to dependent children (ADC).

Tests were constructed to measure the level of achievement of the stated objectives of each of the seven instructional modules developed by the project staff. Table 1 summarizes the results of tests by instructional module and for all modules. For all seven instructional modules, sixty-five (65) percent of the students correctly solved seventy-five (75) percent of the problems. Hence, the level of performance stated in the objective was not attained. On a module by module basis, the stated objective was achieved in the Basic Facts module. Due to classroom time limitations, not all of the Applications module was completed by students prior to testing. Hence, many of the students were tested over materials that had not been presented.

> OBJECTIVE: After receiving 8 weeks of instruction involving a sample of the materials developed for the student instructional package from a trained teacher, 80 percent of the students in the pilot classes will demonstrate an increased level of achievement in mathematics as measured by an appropriate level of the Comprehensive Test of Basic Skills administered on or before April 3, 1978, and on or before May 31, 1978, by the classroom teacher.

The pilot classroom teachers in the Columbus Public Schools administered the Comprehensive Test of Basic Skills (CTBS) to students in their classrooms during the week of April 10, 1978, as part of the standardized testing program of the school system. The two non-public school teachers participating in the study were provided appropriate testing materials to complete the pretest for the project. All teachers were provided appropriate testing materials to complete the posttesting for the project during the week of June 5, 1978.

The criterion for an increased level of achievement on the CTBS for each student was based on the grade equivalent of the total score on the pretest. The pretest grade-equivalent score was divided by grade placement at pretest time to obtain the average growth in achievement per month of instruction. The average growth in achievement per month was multiplied by two and added to the pretest grade-equivalent score to obtain the criterion score. Any student whose posttest grade-equivalent score was greater than or equal to the criterion was considered to have achieved the objective. Only students with pretest and posttest scores on both the CTBS and Attitude Towards Mathematics Scale were included in the analysis. Table 2 summarizes the number and percent of students meeting the criterion by class and for all students.

Table 1

Summary of Number of Classes and Percent of Students Meeting Criteria for the Tests of Module Achievement

Module	Number of Classes	Total Number of Students	Students Meeting Criteria	Classes Meeting Criteria	Percent of Students Meeting Criteria
Basic Facts	3	80	78	3	98
Place Value	6	153	105	2	69
Rounding	4	111	49	1	44
Estimation	3	79	56	0	71
Decimal Computations	3	76	46	1	61
Properties	3	80	61	2	76
Applications	4	90	39	0	43
Total	26	669	434	9	65

Table 2

Summary of Number and Percent of Students Showing Increased Level of Achievement in Mathematics as Measured by the CTBS

Class	Number of Students	Number Showing Increased Achievement	Percent Showing Increased Achievement
A	24	11	46
B	19	6	32
C	11	2	18
D	13	8	62
E	27	20	74
F	19	4	21
G	14	10	71
H	22	11	50
I	27	14	52
Total	176	86	49

The average grade-equivalent change scores from pretest to posttest on the total CTBS and the three subtests are summarized by class and for all students in Table 3. On the average, over the two month period, students gained .8 months on computations, 6.4 months on concepts, 1.9 months on applications, and 2.4 months on the total mathematics scores. The sizeable gain in concepts was offset by the lack of growth in computations. However, many students scored above grade level on the computations pretest and would have had to have shown more than one month of growth for each month of the program to meet the criterion.

Table 3

Summary of Average Changes in Grade Equivalent Scores from Pretest to Posttest on the CTBS by Class and For All Students

Class	N	Computations	Concepts	Applications	Total
A	24	.25	.31	- .21	.21
B	19	- .42	.53	.45	- .05
C	11	- .03	.32	- .59	- .04
D	13	.59	.30	- .10	.29
E	27	.90	.91	.45	.77
F	19	- .38	- .27	- .50	- .36
G	14	.46	.85	.33	.57
H	22	- .30	1.30	1.15	.37
I	27	- .33	.99	.21	.14
Total	176	.08	.64	.19	.24

OBJECTIVE: After receiving 8 weeks of instruction involving a sample of the materials developed for the student instructional package from a trained teacher, 80 percent of the students in the pilot classes will demonstrate an improved attitude toward learning and using mathematics as measured by a scale to be selected administered by the students' classroom teachers on or before April 3, 1978 and on or before May 31, 1978.

The Attitude Towards Mathematics Scale was adapted with permission from earlier work conducted by Dr. Marilyn Suydam of The Ohio State University. The instrument has been used previously with more than 3000 subjects in grades four, five and six with estimated reliabilities greater than .90. Responses to items in the scale with negative stems were reflected and item responses summed to obtain a total score for attitude towards mathematics. The total was constructed such that a higher score is indicative of a more negative attitude towards mathematics.

The total scores for the pretest administered during the week of April 10, 1978, and the posttest administered during the week of June 6, 1978, were compared for each student to determine change in attitude towards mathematics. Only students with pretest and post-test scores on both the CTBS and the Attitude Towards Mathematics Scale were included in the analysis. Table 4 summarizes the number and percent of students showing improved attitudes towards mathematics by class and for all students. In total, 59 percent of the students showed improved attitudes towards mathematics which is less than the 80 percent criterion specified in the objective. One class was close to the criterion with 78 percent of the students exhibiting improved attitudes.

Table 4

Summary of Number and Percent of Students Showing Improved Attitude Towards Mathematics by Class and for All Students

Class	Number of Students	Number Showing Improved Attitude	Percent Showing Improved Attitude
A	24	15	63
B	19	11	58
C	11	3	27
D	13	8	62
E	27	21	78
F	19	10	53
G	14	9	64
H	22	12	55
I	27	14	52
Total	176	103	59

Second Year: 1978-1979

OBJECTIVE: After receiving 26 weeks of instruction involving the student instructional packages from a trained teacher, 80 percent of the students will demonstrate the ability to correctly solve 75 percent of selected problems relating to the objectives of the instruction as measured by a locally constructed test administered by the students' classroom teacher on or before May 18, 1979.

The student instructional package is divided into modules which were field tested by teachers. Revised versions of module achievement tests developed during the first year of the study were administered by the classroom teachers upon completion of a module and forwarded to the project evaluator for analysis. Table 5 shows the degree in which each unit was completed and tested. Student performance will be reported for each module.

Table 5

Frequency of Completed and Uncompleted Instructional Modules

Module	Classes Reporting			Students
	Finished Entire Unit	Finished Most of Unit	Finished Less Than One-Half	
Basic Facts	17	8	2	734
Place Value	9	20	0	731
Decimal Computation	17	9	2	677
Properties & Operations	16	9	1	649
Rounding	17	6	1	644
Estimation	15	5	1	596
Application	9	4	5	497

Table 6 shows the results of the Basic Facts Unit with the number and percent of the students achieving the criterion.

Table 6

Basic Facts

Grade Level	Number of Students Tested	Number of Students Achieving The Criterion	Percent of Students Achieving The Criterion
4	233	214	91.8
5	269	266	98.9
6	232	229	98.7
Total	734	709	96.6

In reviewing Table 6 it is can be noted in Column 4 that all grade levels achieved the stated criterion with an overall 96.6 percent of the students scoring 75 percent correct or better on the Basic Facts Achievement Test.

Table 7 shows the results of the Place Value Test with the number and percent of students achieving the 80 percent criterion. A closer examination of the scores revealed that students in all grade levels were able to identify place values in a particular number but generally not able to respond correctly to other types of items included in the test. Overall, 54.9 percent of the students tested answered 75 percent or more of the items correctly.

The Decimal Computations Test was first administered without the use of a calculator. The same test was given again with students using a calculator to determine the effects of the calculator upon decimal computations. Tables 8 and 9 show the test results for the Decimal Computation Test with the number and percent of students achieving the criterion of 75 percent or more of the items correct.

Table 7

Place Value

Grade Level	Number of Students Tested	Number of Students Achieving The Criterion	Percent of Students Achieving The Criterion
4	287	119	41.5%
5	185	97	52.4%
6	259	185	71.4%
Total	731	401	54.9%

Table 8

Decimal Computation
Without Calculators

Grade Level	Number of Students Tested	Number of Students Achieving The Criterion	Percent of Students Achieving The Criterion
4	204	78	38.2%
5	250	184	73.6%
6	255	223	87.5%
Total	709	485	68.4%

Table 9

Decimal Computation
With Calculators

Grade Level	Number of Students Tested	Number of Students Achieving The Criterion	Percent of Students Achieving The Criterion
4	224	184	82.1%
5	223	196	87.9%
6	230	225	97.8%
Total	677	605	89.4%

In comparing the data from Tables 8 and 9, the effect of using the calculator to increase the performance in decimal computation can be seen. The effect was most evident at the fourth grade level. Fourth grade students increased from 38.2% meeting the criterion without a calculator to 82.1% meeting the criterion using a calculator. Increases were noted in all grades. Overall, an additional 21 percent met the criterion when using a calculator. In general, students did not meet the project objective when taking the Decimal Computations Test without the aid of a calculator. However, as shown in Table 9, this objective was met when a calculator was available.

The results of the Properties Test are shown in Table 10. The fourth and sixth grades achieved the criterion while the fifth was very close to the 80 percent level with 78.6 percent of the students getting 75 percent of the problems correct. Overall, the criterion level was achieved with 80.7 percent of all students getting 75 percent or more correct on the Properties Test.

Table 11 shows the number and percent of students achieving the criterion of 80% getting 75% or more correct on the Rounding Test. The percent of students achieving the criterion on the Rounding Test was the lowest of the seven modules. Overall, 38.1 percent of the students responded correctly to 75 percent or more of the items.

Table 10

Properties

Grade Level	Number of Students Tested	Number of Students Achieving The Criterion	Percent of Students Achieving The Criterion
4*	209	178	85.2%
5	167	147	78.6%
6	253	226	89.3%
Total**	440	373	80.7%

*Separate module for grade four
**Grades 5 and 6

Table 11

Rounding

Grade Level	Number of Students Tested	Number of Students Achieving The Criterion	Number of Students Achieving The Criterion
4	194	48	24.7%
5	216	77	35.6%
6	234	121	51.7%
Total	644	246	38.1%

The results of the Estimation Test are summarized in Table 12. The frequency and percent of students achieving above the 75 percent criterion are shown. Students did not achieve the criterion level of 80 percent scoring 75 percent or more correct. The results suggest that the operation of division was primarily responsible for pulling down the percents. Overall, 57.6 percent of the students achieved 75 percent or more correct on the Estimation Test.

Table 12

Estimation

Grade Level	Number of Students Tested	Number of Students Achieving The Criterion	Percent of Students Achieving The Criterion
4	167	78	46.7%
5	207	121	58.5%
6	222	144	64.9%
Total	596	343	57.6%

Table 13 shows the number and percent of students scoring above the level of 75 percent correct on the Application Test.

Table 13

Application

Grade Level	Number of Students Tested	Number of Students Achieving The Criterion	Percent of Students Achieving The Criterion
4	150	63	42.0%
5	178	70	39.3%
6	169	101	59.8%
Total	497	234	47.1%

Students did not meet the criterion level of 80 percent getting 75 percent or more of the problems correct on the Application Test. Overall, 47.1 percent of the students achieved 75 percent or more correct on the Application Test.

As shown in Table 14, students achieved the criterion in two of the seven modules. In addition, 89.4 percent of the students got 75 percent or more items correct on Decimal Computation Test using a calculator. The data on module tests do not indicate the growth in achievement in the seven modules, but rather indicate the level of performance after instruction.

Table 14

Summary of the
Module Achievement Test

Modules	Percent of Students Scoring 75 Percent or Better on the Module Achievement Test			
	Grade Level			All
	4	5	6	
Basic Facts	91.8	98.9	98.7	96.6
Decimal Computation (Without Calculators)	38.2	73.6	87.5	68.4
Decimal Computation (With Calculators)	82.1	87.9	97.8	89.4
Place Value	41.5	52.4	71.4	54.9
Properties*	85.2	78.6	82.2	80.7
Rounding	24.7	35.6	51.7	38.1
Estimation	24.7	58.5	64.9	57.6
Application	42.0	39.3	59.8	47.1

*Different test administered in grade 4.

OBJECTIVE: After receiving 26 weeks of instruction involving the student instructional packages and a calculator from a trained teacher, 80 percent of the students will exhibit increased levels of achievement in mathematics as measured by appropriate levels of the CTBS administered on or before November 1, 1978, and on or before May 18, 1979, by the classroom teachers.

For evaluation of this objective pretest and posttest scores for computation, concepts, and applications subtests and total score on the CTBS were converted to NCE scores. Pretest and posttest NCE scores for each student were compared to classify the change in the level of achievement from pretest to posttest as either decreased, the same, or improved. Table 15 summarizes the analysis of the total score. Of the 610 students in the calculator and materials classes, 357, or 58.5 percent, exhibited improved achievement in mathematics, and hence the objective was not achieved. In fact, a larger percent (62.9) of the control group showed improved achievement than did the calculator only students (58.4) or calculator and materials students (58.5). The percent of students in each group showing improved levels of achievement from pretest to posttest by subtest of the CTBS are summarized in Table 16. Across the three subtests, the percent of students showing improved levels of achievement from pretest to posttest were among the calculator and materials students. In computations and applications the largest percents of students showing improvement were in the control group. On the concepts subtest the largest percent of improvement was among calculator only students.

Table 15

Changes in Levels of Achievement in Mathematics from Pretest to Posttest by Group

Group	Decreased Achievement	No Change	Increased Achievement
Calculator and Materials	39.0 (238)	2.5 (15)	58.5 (357)
Calculator Only	38.7 (240)	2.9 (18)	58.4 (362)
Control	33.5 (206)	3.6 (22)	62.9 (387)

Table 16

Percent of Students Showing Improved Levels of Achievement from Pretest to Posttest by Treatment Group and Subtest

Subtest	Group	N	Decreased Achievement	No Change	Increased Achievement
Computations	Cal. and Materials	610	38.8	1.0	60.2
	Calculators Only	620	37.7	1.1	61.1
	Control	615	35.0	2.8	62.3
Concepts	Cal. and Materials	610	43.4	2.0	54.6
	Calculator Only	620	37.9	1.8	60.3
	Control	615	39.7	3.1	57.2
Applications	Cal. and Materials	610	46.4	2.3	51.3
	Calculators Only	620	43.7	2.4	53.9
	Control	615	42.8	2.4	54.8

OBJECTIVE: After receiving 26 weeks of instruction involving the student instructional packages and a calculator from a trained teacher, 80 percent of the students will demonstrate an improved attitude toward learning and using mathematics as measured by the Attitude Towards Mathematics Scale administered by the students' classroom teacher on or before November 1, 1979, and on or before May 18, 1979.

The data for this objective are summarized in Table 17. Of the students enrolled in the calculator and materials classes, 39.0 percent showed a more positive attitude toward mathematics at posttest time, and hence, the objective was not achieved. In fact, it is clear from Table 17 that a larger percent of students in both the control classes and calculator only classes exhibited an improved attitude toward mathematics than did the students in the calculator and materials classes. The largest percent of students showing improved attitude was among the control students.

Table 17

Percent of Students Showing Less Positive, The Same, or More Positive Attitude Toward Mathematics from Pretest to Posttest by Treatment Category

Group	More Positive	Same	Less Positive
Calculator and Material	39.0 (238)	3.3 (20)	57.7 (352)
Calculator Only	43.1 (267)	4.0 (25)	52.9 (328)
Control	45.5 (280)	3.3 (20)	51.2 (315)

OBJECTIVE: After receiving 26 weeks of instruction, mean scores of randomly selected classes receiving instruction involving the student instructional packages and calculators from a trained teacher will be significantly higher ($p < .10$) on the posttest CTBS, posttest Attitude Towards Mathematics, and Test of Prediction and Computer Literacy than the means of randomly selected classes using only calculators and randomly selected control classes as determined by a multivariate analysis of covariance of the posttest class means using the pretest class means of the CTBS, Attitude Towards Mathematics, and Test of Prediction and Computer Literacy as covariates. The pretests will be administered on or before November, 1978 and the posttests will be administered on or before May 19, 1979.

The design to test the objective is depicted in Figure 2. Thirty classes from each grade level four, five, and six were randomly assigned to the three treatments with ten classes assigned to each treatment.

For this analysis pretest and posttest scores of students on the CTBS, Attitude Towards Mathematics Scale, and Computer Literacy Test were summed to form a classroom score. The mean classroom score was used to perform the analysis. The CTBS scores are in NCE units while the Attitude Towards Mathematics and Computer Literacy scores are in raw score units.

TREATMENT		Grade 4	Grade 5	Grade 6
I.	Calculators and student instructional packages	10	10	10
II.	Calculators only	10	10	10
III.	Control	10	10	10

Figure 2

A Representation of the Design to Test the Fourth Performance Objective

Inspection of the standard deviations of posttest scores within cells of the design suggests that the homogeniety of variance assumption necessary for a multivariate analysis of covariance could not be met without extensive data transformations. However, the univariate analysis procedures are still valid, and hence, the data for this objective were analyzed using a univariate analysis of covariance of posttest scores with pretest scores as covariates. For each analysis a test of homogeniety of regression was completed prior to conducting the analysis of covariance. The hypothesis of homogeniety of regression in all cells was not rejected for any of the analyses reported.

The analysis of the posttest total score in mathematics derived from the CTBS is summarized in Table 18. The main effect for grade level was significant ($p < .001$). A comparison of the three grade level posttest means adjusted for the pretest using the Newman-Keuls procedure indicates that the fifth grade scored significantly ($p < .10$) higher than the fourth grade and that the sixth grade scored significantly ($p < .10$) higher than the fourth grade.

The data for the Newman-Keuls procedure are summarized in Table 19. Pretest and posttest means for each cell of the design are summarized in Table 20.

The analysis of posttest scores in computations derived from the CTBS is summarized in Table 21. The main effect for grade level was significant ($p < .10$). A comparison of the three grade level posttest means adjusted for the pretest using the Newman-Keuls procedure indicates that the fourth grade scored significantly ($p < .10$) higher than the fifth grade and that the sixth grade scored significantly ($p < .10$) higher than the fifth grade.

Table 18

Summary of an Analysis of Covariance of Posttest Scores on CTBS Total Score with Pretest Scores as a Covariate

Source	SS	df	MS	F
Regression	14247.5	1	14247.5	715.653*
Treatment	12.6	2	6.3	.315
Grade	284.8	2	142.4	7.154*
Treatment x Grade	117.3	4	29.3	1.473
Error	1513.0	76	19.9	

*p < .001

Table 19

Summary of Newman-Keuls Procedure for Differences Between Means of Grade Levels on CTBS Total Score

Group 1	Group 2	Mean Group 1	Mean Group 2	Difference	Rank Difference
Grade 6	Grade 5	52.80	51.28	1.51	1
Grade 5	Grade 4	51.28	48.24	3.04	1*
Grade 6	Grade 4	52.80	48.24	4.56	2*

*p < .10

Table 20

Pretest and Posttest Means and Standard Deviations of the CTBS Total Score for Each Cell of the Design

	Group	Pretest Mean	Pretest S.D.	Pretest N	Posttest Mean	Posttest S.D.	Posttest N
Grade 4	Cal. and Materials	61.45	12.29	10	56.10	12.30	10
	Calculator Only	51.95	18.90	10	48.86	22.49	10
	Control	63.35	8.88	10	59.10	11.33	10
Grade 5	Cal. and Materials	48.02	13.90	9	48.44	15.21	9
	Calculator Only	48.31	11.01	9	45.50	11.66	9
	Control	50.24	14.3	9	47.32	15.49	9
Grade 6	Cal. and Materials	46.81	6.85	10	47.32	6.41	10
	Calculator Only	51.20	11.83	9	49.78	11.74	9
	Control	52.76	13.29	10	53.01	15.88	10

Table 21

Summary of an Analysis of Covariance of Posttest Scores on Computations with Pretest Scores as a Covariate

Source	SS	df	MS	F
Regression	5912.20	1	5912.20	44.55*
Treatment	27.59	2	13.80	.10
Grade	1773.89	2	886.95	6.68**
Treatment x Grade	233.61	4	58.40	.44
Error	10085.17	76	132.70	

*$p < .001$

**$p < .002$

The data for the Newman-Keuls procedure are summarized in Table 22. Pretest and posttest means for each cell of the design are summarized in Table 23.

The analysis of posttest scores on concepts derived from the CTBS is summarized in Table 24. The main effect for grade level was significant ($p < .001$). A comparison of the three grade level posttest means adjusted for the pretest using the Newman-Keuls procedure indicates that fourth graders scored significantly ($p < .10$) higher than sixth graders and fifth graders. The data for the Newman-Keuls procedure are summarized in Table 25. Pretest and posttest means for each cell of the design are summarized in Table 26.

The analysis of posttest scores in applications derived from the CTBS is summarized in Table 27. None of the effects were significant. The pretest and posttest means for each cell of the design are summarized in Table 28.

Table 22

Summary of Newman-Keuls Procedure for Differences Between Means of Grade Levels on Computations

Group 1	Group 2	Mean Group 1	Mean Group 2	Difference	Rank Difference
Grade 6	Grade 4	57.05	52.05	5.00	2
Grade 4	Grade 5	52.05	45.25	6.80	2*
Grade 5	Grade 5	57.05	45.25	11.80	3*

*$p < .10$

Table 23

Pretest and Posttest Means and Standard Deviations of Computations for Each Cell of the Design

	Group	Pretest Mean	Pretest S.D.	Pretest N	Posttest Mean	Posttest S.D.	Posttest N
Grade 4	Cal. and Materials	49.49	12.30	10	53.15	11.63	10
	Calculator Only	44.63	15.36	10	49.07	22.15	10
	Control	52.37	9.98	10	56.12	12.05	10
Grade 5	Cal. and Materials	53.03	7.11	9	50.48	14.82	9
	Calculator Only	47.56	8.83	9	46.20	12.07	9
	Control	53.99	7.30	9	47.92	15.31	9
Grade 6	Cal. and Materials	42.54	4.13	9	52.21	7.38	9
	Calculator Only	44.33	7.45	9	50.98	12.41	9
	Control	43.87	14.46	10	56.60	16.49	10

Table 24

Summary of an Analysis of Covariance of Posttest Scores on Concepts with Pretest Scores as a Covariate

Source	SS	df	MS	F
Regression	8445.07	1	8445.07	136.66*
Treatment	153.84	2	76.92	1.245
Grade	673.09	2	336.55	5.446**
Treatment x Grade	19.95	4	4.99	.081
Error	4696.66	76	61.80	

*$p < .001$

**$p < .006$

Table 25

Summary of Newman-Keuls Procedure
for Differences Between Means
of Grade Levels on Concepts

Group 1	Group 2	Mean Group 1	Mean Group 2	Difference	Rank Difference
Grade 4	Grade 6	50.35	44.78	5.57	2*
Grade 6	Grade 5	44.78	44.24	.54	2
Grade 4	Grade 5	50.35	44.24	6.11	3*

*$p < .10$

Table 26

Pretest and Posttest Means and Standard
Deviations of Concepts for Each
Cell of the Design

	Group	Pretest Mean	Pretest S.D.	Pretest N	Posttest Mean	Posttest S.D.	Posttest N
Grade 4	Cal. and Materials	49.39	11.64	10	49.19	9.90	10
	Calculator Only	42.51	14.10	10	46.40	19.02	10
	Control	49.37	12.90	10	52.23	11.66	10
Grade 5	Cal. and Materials	53.70	8.75	9	47.58	14.33	9
	Calculator Only	44.22	8.72	10	42.43	10.61	10
	Control	48.92	12.63	9	44.14	15.09	9
Grade 6	Cal. and Materials	48.72	5.82	9	42.84	7.51	9
	Calculator Only	46.98	9.39	9	45.11	10.13	9
	Control	51.64	18.61	10	48.37	15.02	10

Table 27

Summary of an Analysis of Covariance of Posttest Scores on Applications with Pretest Scores as a Covariate

Source	SS	df	MS	F
Regression	7661.36	1	7661.36	244.827*
Treatment	38.61	2	19.31	.617
Grade	119.47	2	59.73	1.909
Treatment x Grade	193.71	4	48.43	1.548
Error	2378.27	76	31.29	

*$p < .001$

Table 28

Pretest and Posttest Means and Standard Deviations of Applications for Each Cell of the Design

	Group	Pretest Mean	Pretest S.D.	Pretest N	Posttest Mean	Posttest S.D.	Posttest N
Grade 4	Cal. and Materials	47.25	9.62	10	48.55	12.47	10
	Calculator Only	45.67	6.29	10	42.90	15.14	10
	Control	46.95	13.46	10	50.15	12.45	10
Grade 5	Cal. and Materials	49.88	5.97	9	52.93	7.78	9
	Calculator Only	42.42	6.84	10	44.73	8.73	10
	Control	47.07	12.49	9	51.00	10.55	9
Grade 6	Cal. and Materials	42.20	6.21	9	43.60	4.76	9
	Calculator Only	42.60	7.15	9	43.97	8.01	9
	Control	47.58	11.68	10	46.5	10.42	10

The analysis of posttest scores on attitude towards mathematics is summarized in Table 29. The main effect for grade level was significant ($p < .10$). A comparison of the three grade level posttest means adjusted for the pretest using the Newman-Keuls procedure indicates that sixth grade scored significantly ($p < .10$) higher than the fifth grade and the fourth grade. Higher scores are indicative of a less positive attitude toward mathematics. The data for the Newman-Keuls procedure are summarized in Table 30. Pretest and posttest means for each cell of the design are summarized in Table 31.

The analysis of posttest scores in computer literacy is summarized in Table 32. None of the effects were significant. The pretest and posttest means for each cell of the design are summarized in Table 33.

Among the six analyses of covariance performance, none of the analyses showed a significant difference among the posttest mean of the three treatment groups. Hence, the objective was not achieved. In four of the six analyses significant differences among the means of the three grade levels were identified. However, grade level differences are not related to the objectives of the study, and detailed discussion of the grade level differences will not be presented in this report.

During the field test the project staff observed a systematic random sample of classes in all three treatment groups and recorded the number of minutes of instructional time for mathematics. Calculator and materials classes were observed nine times, calculator only classes four times, and control classes two times. The instructional time spent on mathematics was averaged across observations to determine an average mathematics instruction time for each class. The data on average mathematics instruction time is summarized in Table 34. Since the average minutes for instructional time for mathematics was greater in the calculator and materials group, the use of instructional time as a blocking variable in the analysis was considered. However, there is not a set of categories of instructional time which when applied to the instructional time data results in a design with every cell having at least two observations. Hence, an analysis of achievement blocking on instructional time could not be completed.

Facilitating Objectives

In order to develop the math calculator materials and select an appropriate hand calculator, a certain number of activities had to be completed by the project staff. These facilitating objectives are discussed in this section.

Table 29

Summary of an Analysis of Covariance of Posttest Scores on Attitude Towards Mathematics with Pretest Scores as a Covariate

Source	SS	df	MS	F
Regression	724.28	1	724.28	31.80*
Treatment	59.72	2	29.86	1.31
Grade	127.10	2	63.55	2.79**
Treatment x Grade	57.05	4	14.26	.626
Error	1731.09	76	22.78	

*p < .001

**p < .07

Table 30

Summary of Newman-Keuls Procedure for Differences Between Means of Grade Levels on Attitude Toward Mathematics

Group 1	Group 2	Mean Group 1	Mean Group 2	Difference	Rank Difference
Grade 6	Grade 5	65.59	63.36	2.23	2*
Grade 5	Grade 4	63.36	62.69	.67	2
Grade 6	Grade 4	65.59	62.69	2.90	3*

*p < .10

Table 31

Pretest and Posttest Means and Standard Deviations of Attitude Scores for Each Cell of the Design

	Group	Pretest Mean	Pretest S.D.	Pretest N	Posttest Mean	Posttest S.D.	Posttest N
Grade 4	Cal. and Materials	62.08	8.13	10	65.20	6.65	10
	Calculator Only	59.98	3.93	10	59.73	4.11	10
	Control	59.95	9.23	10	61.82	5.36	10
Grade 5	Cal. and Materials	58.30	5.43	9	62.72	3.95	9
	Calculator Only	62.35	6.14	10	63.80	5.91	10
	Control	61.66	7.75	9	62.36	4.63	9
Grade 6	Cal. and Materials	59.80	4.25	9	64.94	6.42	9
	Calculator Only	65.03	5.02	9	66.74	6.99	9
	Control	65.46	8.03	10	57.52	5.92	10

Table 32

Summary of an Analysis of Covariance of Posttest Scores on Computer Literacy with Pretest Scores as a Covariate

Source	SS	df	MS	F
Regression	30.29	1	30.29	39.31*
Treatment	.48	2	.24	.312
Grade	2.09	2	1.04	1.354
Treatment x Grade	1.99	4	.50	.645
Error	58.56	76	.77	

*$p < .001$

Table 33

Pretest and Posttest Means and Standard Deviations of Computer Literacy for Each Cell of the Design

	Source	Pretest Mean	Pretest S.D.	Pretest N	Posttest Mean	Posttest S.D.	Posttest N
Grade 4	Cal. and Materials	10.38	1.47	10	10.95	1.53	10
	Calculator Only	9.64	.82	10	10.94	1.17	10
	Control	10.08	1.23	10	10.87	1.12	10
Grade 5	Cal. and Materials	10.79	.67	9	11.88	.83	9
	Calculator Only	10.39	.69	10	11.22	.91	10
	Control	10.70	1.44	9	11.36	.99	9
Grade 6	Cal. and Materials	11.24	.75	9	12.22	.94	9
	Calculator Only	11.04	.93	9	11.91	.73	9
	Control	11.73	.79	10	12.08	1.15	10

Table 34

Summary of Average Mathematics Instruction Time by Grade Level and Treatment

Group	Grade	Average	Minimum	Maximum
Calculator and Materials	4	63.2	43	101
	5	66.3	36	85
	6	61.4	43	90
Calculator Only	4	46.9	40	55
	5	48.3	32	63
	6	47.3	38	61
Control	4	45.5	30	64
	5	46.9	30	70
	6	41.9	34	53

First Year: 1978-1979

OBJECTIVE: To compile a list of pertinent available materials, research, literature related to the development of mathematics skills, and the use of calculators with elementary school children.

The evaluator in consultation with the project staff developed a rating scale to be used by experts in mathematics education in evaluating the completion of this facilitating objective. The rating scale required the expert to: 1) determine if there is evidence that the staff completed the activities specified in the objective, 2) judge the adequacy of the search, 3) verify that the results of the search were utilized in the compilation of the pertinent materials, and 4) make suggestions and comments for improvement of the search.

The project staff met with Dr. Marilyn Suydam, Professor of Mathematics Education at The Ohio State University, and Dr. Laureen Woodby, Visiting Professor of Mathematics Education at The Ohio State University, on October 26, 1977, to present and discuss the activities and products related to the objective. Dr. Suydam and Dr. Woodby validated the occurrence of the search and indicated that it was very adequately accomplished.

OBJECTIVE: To prepare a set of guidelines to select appropriate materials from those identified by the query search for use in the project and purchase these materials.

The project evaluator developed a five point rating scale which experts used to rate each guideline for selection of appropriate materials. On October 6, 1977 the project staff presented the guidelines to a panel of four experts who gave their ratings of each guideline to the project evaluator. The panel rated each of the seven guidelines using a five point scale ranging from very inappropriate to very appropriate. Four guidelines were rated as appropriate or very appropriate by all four panel members. The project staff, based on the advice of the panel, revised two guidelines. A third guideline which received a satisfactory rating was not modified.

OBJECTIVE: To develop evaluation criteria for the hand held calculator.

A panel of experts in mathematics education comprised of Earl Tharp, Supervisor of Mathematics for the Columbus Public Schools, Dr. Laureen Woodby, Visiting Professor of Mathematics Education at The Ohio State University, and Dr. Marilyn Suydam, Professor of Mathematics Education at The Ohio State University, was convened on November 22, 1978, to review the criteria for selection of a hand held calculator.

After hearing a presentation by the project staff, members of the panel offered suggestions for improvement of the criteria and rated the criteria employing a scale provided by the project evaluator.

All three consultants found evidence that the project team: 1) had examined available calculators, 2) consulted with persons who had experience using calculators with children and 3) reviewed the literature on the use of calculators with children. All three consultants agreed that the criteria was appropriate both in terms of content and ranking with the exception of storage of numerical data. The consultants indicated that this feature should be a higher priority.

OBJECTIVE: To develop student instructional packages.

The project staff wrote seven instructional modules to be used in grades four, five and six with hand held calculators. As each module was written, the module and a Likert rating scale were sent to consultants for critiquing and rating. The consultants consisted of local teachers and national experts in the field of mathematics education. The consultants were asked to rate the module in the thirteen areas of clearness of objectives, reading level of the materials, teacher directions, pupil directions, appropriate subject content, suitable instructional exercises, sequence of lessons, range of difficulty, interesting problems, appropriate number of exercises, format of lessons, appropriate for other grade levels, and completeness of activities. The project staff used the ratings, comments, and suggestions from the consultants to revise the modules before the unit was piloted in classrooms. During the field testing phase, the pilot teachers were asked to rate the modules using the same rating scale as the consultants.

The consultants and teachers rated each module in each of thirteen areas. Tables 35 and 36 give a summary of the ratings by consultants and pilot teachers respectively. The ratings have been summarized into three categories of satisfactory, undecided and unsatisfactory. The consultants' ratings ranged from a low of 65.0 percent satisfactory ratings of the place value module to a high of 94.4 percent satisfactory ratings of the rounding module. With the exception of the rounding module, pilot teachers gave higher ratings to modules than the consultants did.

Second Year: 1978-1979

OBJECTIVE: To prepare final copy and distribute student instructional packages to teachers receiving both calculators and instructional packages.

Table 35

Ratings of the Math Calculator Instructional Modules Before Pilot Testing by Consultants

	Ratings by Consultants			
	Satisfactory	Undecided	Unsatisfactory	Consultants
Place Value	65.0%	10.8%	24.2%	8
Properties	85.6%	5.8%	8.6%	8
Decimal Computation	87.2%	7.7%	5.1%	3
Rounding	94.4%	2.8%	2.8%	9
Estimating	87.4%	1.9%	6.7%	8
Basic Facts	87.7%	5.4%	6.9%	10
Application	78.2%	10.3%	11.5%	6
Decimal Computation	68.8%	7.8%	23.4%	6
Overall Rating	82.6%	6.2%	11.2%	

*After first revision

Table 36

Ratings of the Math Calculator Instructional Modules by Pilot Teachers

	Ratings by Teachers		
	Satisfactory	Undecided	Unsatisfactory
Place Value	85.0%	5.0%	10.0%
Properties	92.3%	0.0%	7.7%
Decimal Computation	88.5%	3.8%	7.7%
Rounding	82.1%	2.6%	15.4%
Estimating	92.6%	3.7%	3.7%
Basic Facts	97.4%	0.0%	2.6%
Application	92.3%	3.8%	3.9%
Overall Rating	89.5%	2.7%	7.8%

The critiquing, rewriting, and pilot testing proved to be very worthwhile procedures in producing the student instructional packages. The project staff benefited greatly by having several math educators review and offer suggestions to improve the modules. The project staff reviewed each module and made necessary changes for smooth implementation of the materials in the field test phase of the project. The instructional materials were printed and distributed to the field test teachers. Teachers received modules on a timely schedule for instruction.

OBJECTIVE: To systematically observe classes receiving calculators and instructional materials and produce a summary of instructional activities in those classrooms.

The project staff developed a form for recording observations that included the date, the teacher, the instructional unit observed, the number of students, any errors encountered in the materials, any implications for revision of the materials, and a description of the type of activities occurring (e.g., lecture, question and answer, etc.). The staff developed a procedure for scheduling observations of classes that insured that every teacher in each treatment group would be observed the same number of times, observations were scheduled while the student instructional packages were in use and while the regular materials were in use, and all student instructional modules would be observed in use in classrooms.

The evaluation of this objective occurred in two steps. A panel composed of the supervisor of mathematics for the Columbus Public Schools, like officials of the participating non-public school systems, and a statistical consultant from the Department of Management Planning and Information of the Columbus Public Schools was convened during the last week of October, 1978. The panel judged: 1) the appropriateness of the procedures developed by the project staff for observing the classes, 2) the appropriateness of the forms developed by the project staff for recording information to be utilized in revising the student instructional packages, and 3) the adequacy of the sampling procedures for observing classes. The three consultants felt the procedures that were developed would enable the staff to have a good understanding of the interactions in the classroom while the project materials were used and the interactions in the room during non-calculator time.

The second step in evaluating this objective was to determine the extent to which the scheduled observations were completed. Table 37 summarizes the completed observations. The project staff satisfactorily completed the observation schedule that was planned. The data collected was used in the final revision of the instructional modules.

Table 37

Classroom Observations Schedule
for Each Experimental Group

Group	Scheduled Observations	Completed Observations	Percent Completed
Calculators and Materials	270	254	94.1%
Calculators Only	120	120	100%
Control	60	60	100%
Total	450	434	96.4%

OBJECTIVE: To revise the student instructional packages based upon the results of systemic observation.

During the period from the first week of December, 1978, through the first week of June, 1979, the project staff summarized their observations of the classes using an instructional module whenever all teachers had completed the module. Combining their notes with the item analysis of the tests of module achievement, the staff made revisions to the module. During the third week of June, 1979, a panel of three experts in mathematics education reviewed the revisions which the staff made to the modules. The three panel members concurred that the staff made revisions to the instructional modules based on data from classroom observations, teacher comments, and item analysis data from the module achievement tests. The panel members rated the revisions as very effective to effective. The panel members felt that the changes in the modules were minor in nature and that the revised units still reflected the same treatment which was implemented in the field test phase of the project.

Teacher Performance Objectives

First Year: 1977-1978

OBJECTIVE: After completing the teacher training package, 90 percent of the teachers selected for the pilot test of the student instructional package will be able to respond correctly to 80 percent of the items included in the posttest of the teacher training package administered to the teachers on or before March 31, 1978.

The Teacher Training Package Posttest was developed to measure eleven behavorial objectives of the Teacher Training Package. The evaluator in consultation with the project staff developed the posttest. The posttest is comprised of two parts. The first part is designed to be completed using only paper and pencil and measures knowledge of mathematical terms, the ability to perform the computations included in the student instructional modules, knowledge of the function of the keys on the calculator, and knowledge of the result of pressing calculator keys in a specified sequence. The second part of the test is designed to be completed using a calculator and the Teacher Reference Manual. This test measures the ability to perform selected arithmetic operations with a calculator and to locate selected information in the manual.

The first part of the posttest consisted of 65 items, and the second part consisted of 13 items. The results of the posttest are summarized in Table 38. Since all nine teachers responded correctly to more than eighty percent of the items, the performance objective was achieved.

Table 38

Summary of Results of Pilot Teacher Training Package Posttest by Subtest and Total Scores

Teacher	Subtest 1	Subtest 2	Total	Percent Correct
1	61	12	73	94
2	55	13	68	87
3	62	13	75	96
4	62	13	75	96
5	57	13	70	90
6	58	12	70	90
7	60	12	72	92
8	56	12	68	87
9	59	12	71	91
Total Correct	530	112	642	
Percent Correct	91	96	91	

Mean = 71.3

Facilitating Objectives

In order to develop the Teacher Training Package for the project, many activities and strategies were planned for the workshops. The facilitating objectives are listed below with results of the evaluation.

First Year: 1977-1978

OBJECTIVE: To develop a teacher training package.

The project staff contacted Dr. Laureen Woodby, The Ohio State University, Visiting Professor of Mathematics Education, Dr. Marilyn Suydam, The Ohio State University, Professor of Mathematics Education, and Mr. Earl Tharp, Supervisor of Mathematics, Columbus Public Schools, to serve as consultants in evaluating the Teacher Training Package. The Teacher Training Package was presented by the project staff, February 10, 1978. A rating scale was provided for consultants' responses.

The three consultants were in agreement as to the content and the schedule of activities for the training package. However, one consultant was undecided as to whether the activities that were scheduled for the training sessions covered the objectives of the training package. This same consultant also was not in agreement with the other two consultants on the clarity of the objectives. He felt the objectives needed additional work.

The three consultants were in agreement to the adaptability of the training package to the range of mathematical skills generally found among elementary teachers. All three consultants felt the Teacher Training Package contained the necessary components to provide teachers with the appropriate knowledge of using hand held calculators in the elementary classroom and to provide the necessary skills in implementing the project in their respective classrooms.

Two of the consultants had some reservations about the ability of the staff to cover the Teacher Training Package thoroughly in twenty instructional hours.

Second Year: 1978-1979

OBJECTIVE: To provide calculators and instruction on operating procedures and to provide logistics for maintaining security of calculators to teachers receiving only calculators for use in their classrooms.

Second Year: 1978-1979

OBJECTIVE: After completing the teacher training package 90 percent of the teachers selected for the field test of the student instructional package will be able to respond correctly to 80 percent of the items included in the posttest of the teacher training package administered to the teachers on or before November 30, 1978.

The Teacher Training Package Posttest was developed to measure eleven behavioral objectives of the Teacher Training Package. The evaluator in consultation with the project staff developed the posttest. The posttest is comprised of two parts. The first part is designed to be completed using only paper and pencil and measures knowledge of mathematical terms, the ability to perform the computations included in the student instructional modules, knowledge of the function of keys on the calculator, and knowledge of the result of pressing calculator keys in a specified sequence. The second part of the test is designed to be completed using a calculator and the Teacher Reference Manual. This test measures the ability to perform selected arithmetic operations with a calculator and to locate selected information in the manual.

After twenty hours of inservice training, the posttest was administered to the teachers. Twenty-four of the thirty teachers responded to the instrument.

From Table 39 the data for the posttest indicate that the objective was met. In fact, all twenty-four teachers who responded to the posttest met the objective.

Table 39

Summary of Results of Teacher Training Package Posttest Scores by Subtest and Total

Number Getting Eighty Percent Correct	Number Tested	Percent Meeting the Objective
24	24	100

The project staff conducted two workshops for teachers who were assigned to the calculators only group (October 12, and 25, 1978). The teachers received instructions on maintaining security of calculators in their classrooms, procedures for acquiring batteries, replacements, and repairs of calculators, and instruction on how to operate the calculators.

Twenty-three of the thirty teachers were present for the second workshop session at which posttesting occurred. Twenty-two teachers responded correctly to all items which measured teachers ability to match calculator keys with their function. Ninety-six percent of the teachers scored 100% on this particular phase of the posttest. Teachers were tested on operation procedures for producing correct answers on the calculators. Eighty-seven percent of those teachers tested correctly answered 80 percent or more of a list of elementary mathematics problems. Ninety-six percent of the teachers correctly listed two or more measures which one could take in managing and organizing calculators in the classroom.

OBJECTIVE: To provide inservice to all teachers participating in the project on the testing and observation procedures required by the project.

During the month of October, 1978, the project staff conducted a two-hour workshop for all teachers participating in the study to familiarize them with the observation and evaluation procedures which were required during the project. The workshop included information on standardized testing procedures, reports of test results which would be distributed to teachers, and the observations that the project staff would conduct. The calculator and materials, calculator only, and control group teachers received separate workshops.

During the months of October, November, and December, 1978, the project staff conducted twenty hours of inservice for the thirty teachers in the calculator and materials classes. Teachers were asked to give their perceptions of each of the workshops sessions using a Calculator Teacher Training Rating Scale which was administered at each session.

Teachers were very positive in their ratings of the workshops. Table 40 summarizes the results of the rating scale for all of the sessions. The data indicates that the workshops were beneficial to teachers in enabling them to have an understanding of their role in the project. Teachers were given the opportunity to list ideas or concepts that needed to be clarified. The project coordinator responded to these concerns at the beginning of the next session.

Table 40

Calculator Project
Teacher Training Workshop

Calculator and Materials Group

What was your overall impression of the calculator project inservice meeting?	Waste of Time 1	2	3	4	Valuable 5
Average Response				4.7	
How well were the materails presented in assisting you in understanding your part of the project?	No Help 1	2	Somewhat Helpful 3	4	Very Helpful 5
Average Response				4.6	
To what extent were you able to ask questions about the concepts presented?	None 1	2	To Some Extent 3	4	Considerable 5
Average Response				4.8	
Were questions answered well by the staff?	No 1	2	Somewhat 3	4	Yes 5
Average Response				4.8	

Teachers in the calculator only group were asked to give their reactions to the and the usefulness of the information that was presented during their two workshops. Teachers indicated both sessions were very valuable to them in gaining an understanding of the project and knowledge of their role in the evaluation strategy. Teachers indicated that the presentations by the project staff were very helpful to them. Teachers felt they had an opportunity to ask questions and most felt that their questions were answered clearly and completely by the project staff. Table 41 shows the results of the ratings by teachers for the two sessions.

Table 41

Calculator Project
Teacher Training Workshop

Calculator Only Group

What was your overall impression of the calculator project inservice meeting?	Waste of Time 1	2	3	4	Valuable 5	
Average Response						4.8
How well were the materials presented in assisting you in understanding your part of the project?	No Help 1	2	Somewhat Helpful 3	4	Very Helpful 5	
Average Response						4.8
To what extent were you able to ask questions about the concepts presented?	None 1	2	To Some Extent 3	4	Considerable 5	
Average Response						4.8
Were questions answered well by the staff?	No 1	2	Somewhat 3	4	Yes 5	
Average Response						4.9

Eighteen of the thirty control group teachers attended a two hour workshop. Those teachers who were not in attendance had individual conferences with a member of the project staff to explain the evaluation strategy and answer questions. As indicated from Table 42 teachers regarded the workshop as being very positive. Teachers felt they had a good understanding of the project and their role. They felt there was adequate opportunity to ask questions about the various facets of the project.

Table 42

Calculator Project
Teacher Training Workshop

Control Group

What was your overall impression of the calculator project inservice meeting?	Waste of Time 1	2	3	4	Valuable 5	
Average Response					4.8	
How well were the materials presented in assisting you in understanding your part of the project?	No Help 1	2	Somewhat Helpful 3	4	Helpful 5	
Average Response					4.7	
To what extent were you able to ask questions about the concepts presented?	None 1	2	To Some Extent 3	4	Considerable 5	
Average Response					5.0	
Were questions answered well by the staff?	No 1	2	Somewhat 3	4	Yes 5	
Average Response					4.7	

Additional Evaluation Activities

First Year: 1977-1978

Parent Survey

The evaluation staff and the project staff developed an instrument for surveying the parents of students involved in the pilot testing of student instructional packages to determine their attitudes toward the use of calculators in mathematics classes and toward the instruction on the use of calculators received by their children.

Two hundred fifty-three surveys were mailed the second week of June, 1978, to parents of students involved in the project. By the second week of July, 1978, one hundred four surveys were returned. This is a 41 percent return. Frequency distributions and percents were used to analyze the survey for the total group of classes. Data from the survey are summarized in Table 43.

Prior to the start of the project pilot teachers sent letters to parents informing them of the calculator project. The survey indicated that eighty-nine percent of those parents responding were aware of the project. Forty-three percent of the parents who responded indicated some reservations and concerns about the use of calculators in a math class. However, only six percent felt compelled enough to call the school and ask questions about their concerns. Approximately the same number had visited the classroom during the time calculators were in use. Sixty-nine percent of the parents who responded saw some of the prepared calculator instructional materials. When parents were asked about their opinions of the use of calculators in the math class, fifty-seven percent were in favor of it. Thirty-three percent were still undecided about the use of calculators in elementary classrooms. Approximately the same number of parents who were favorable to the use of calculators in math classes indicated a willingness to have their children participate in such a program again. The same number of parents who were undecided about the use of calculators in math classes were undecided about their children's involvement again.

Parents were concerned that their children would not learn their basic mathematics facts and skills. Many parents felt their children would soon forget these basic skills and become dependent on the calculator. However, since the calculator is readily available and inexpensive and will probably be used by their children, it would probably be an acceptable educational approach provided that mental abilities in mathematics are not compromised. Parent comments emphasized the point that calculators should be used only under controlled conditions.

Second Year: 1978-1979

Parent Survey

During the month of June, 1979, surveys were mailed to parents of students in the calculator and materials group and to parents of students in the calculator only group. The purpose of the survey was to determine the attitudes of parents towards the use of calculators in mathematics classes and towards the instruction on the use of calculators received by their children.

Table 44 shows the number of parents surveyed and the return rate for the survey.

Table 43

Total Group Response
to Parent Survey

	Yes	No	No Response
Were you aware of the project before it started?	89.4%	10.6%	
Do you have concerns about the use of calculators in the classroom?	43.3%	56.7%	
Did you talk to anyone about your concerns?	6.7%	80.8%	12.5%
Have you observed classes using the calculator?	6.7%	93.3%	
Did your child bring materials home?	69.2%	29.8%	1.0%
Do you have a calculator in your home?	87.5%	12.5%	
Does your child use a calculator to do homework?	39.4%	59.6%	1.0%
Does your child like math better since the calculator project?	56.7%	24.0%	19.2%
Would you like your child to continue to use the calculator?	55.8%	30.8%	13.5%

Table 44

Calculator Math Project
Parent Survey

	Mailed Surveys	Returned Surveys	Percent Returned
Calculator and Materials	798	279	35.0
Calculator Only	799	261	32.7
Total	1597	540	33.8

The percent of return was not as large as desired. The statements made about the results may not be generalizable to all parents with children in the project but are accurate for the subset that returned the survey.

The survey indicates that the calculator and material group parents were more aware of the project than the calculator only group of parents. Little more than fifty percent of the calculator only parents had information about the project before it started. Seventy-seven percent of the calculator and material parents were aware of the project before it started.

Even though invitations were extended by teachers for parent visitations, less than ten percent of the parents observed classes while calculators were being used. Of the parents whose children were in the calculator-materials group, eighty-five percent indicated they had seen the types of materials being used with calculators.

Little more than fifty percent of both groups of parents indicated that their children liked math better since the calculator project began. Approximately the same percent felt that they would like their children to continue using a calculator in math class. However, fifteen percent of both groups indicated that they would not want their children using calculators in class. These parents believed their children would lose their computational skills and would become dependent on their calculator for basic facts skills.

Of the 540 parents who responded to the survey, thirty-eight percent felt that their children should have the basic mathematical fundamentals first before using machines that would permit the child to work math problems. Parents were asked if they had concerns about the use of calculators in the classroom before the project started. The data indicated almost half of the parents in both groups were concerned about the project. Additional analysis revealed that twenty-five percent of the parents with concerns before the project started were still skeptical about the instructional value of such a project. Almost twenty percent of the calculator-material parents discussed their concerns with the teacher or principal. Some parents stated that after hearing the explanation about the operation of the project and seeing the types of prepared materials for children, they felt better about the project. Less than ten percent of the calculator only parents contacted the school about their concerns. Most of the parents who were favorable at the start of the project were still convinced at the conclusion of the project of the value calculators have in the instructional setting. Six percent of the parents indicated a change of attitude and felt that they would not want their child to continue using the calculator in math classes.

At the end of the project, more than fifty percent of each group of parents were favorable to the use of calculators in math classrooms. Sixty-one percent of the calculator-material group of parents were favorable to the use of calculators in the math class. Several parents expressed appreciation of the opportunity for their children to be exposed to calculators in a meaningful situation. The fact that one group of children used specially designed instructional materials for calculators did not seem to effect the feeling of parents.

Tests With Calculators

All students were tested without calculators at the completion of the project with an appropriate level and form of the CTBS. However, to test the effect that using a calculator would have on scores on the standardized test, some students were tested again and allowed to use calculators.

One week after the posttest with the CTBS, students in grades four, five, and six of the calculator and materials classes took the same test as the posttest, with the same time limits, but they were permitted to use calculators. The average number of problems correctly completed with and without calculators for each grade level and subtest are summarized in Table 45. In every instance, except fifth grade applications, the average number correct with a calculator exceeds the average number correct without a calculator. The greatest differences between raw scores with and without calculators were in the computations subtest. Differences between the average number correct

Table 45

Summary of Raw Scores on the CTBS by Grade Level for Tests Taken With and Without a Calculator

Subtest		Grade 4*	Grade 5**	Grade 6***
		Raw Scores		
		Mean	Mean	Mean
Computations (possible=48)	without calculator	31.69	34.85	26.96
	with calculator	36.50	39.12	30.33
Concepts (possible=30	without calculator	16.35	20.89	17.66
	with calculator	16.52	20.95	17.98
Applications (possible=20)	without calculator	8.81	12.40	9.89
	with calculator	9.26	12.12	10.06
Total (possible-98)	without calculator	56.85	68.13	54.51
	with calculator	62.29	72.19	58.37
		(N=208)	(N=215)	(N=207)

*CTBS Level 2 Form R

**CTBS Level 2 Form Q

***CTBS Level 3 Form R

with and without calculators are less than one for the concepts and applications test. That is, the calculator was of little value in increasing scores in concepts and applications. If the average total raw scores with and without calculators are interpreted with respect to appropriate grade equivalent norms, the average fourth grader scored 3 months higher, the average fifth grader scored 3 months nigher, and the average sixth grader scored 4 months higher with a calculator than without. The grade equivalents of average raw scores are presented in Table 46.

Table 46

Summary of Grade Equivalent Scores
of Average Raw Scores of the CTBS
by Grade Level With and Without
a Calculator

Subtest		Grade 4*	Grade 5**	Grade 6***
Computations	without calculator	5.0	5.3	6.5
	with calculator	5.7	5.9	7.2
Concepts	without calculator	4.7	5.6	7.0
	with calculator	4.9	5.6	7.0
Application	without calculator	4.7	5.3	6.1
	with calculator	4.7	5.3	6.1
Total	without calculator	4.9	5.4	6.5
	with calculator	5.2	5.7	6.9

*CTBS Level 2 Form R

**CTBS Level 2 Form Q

***CTBS Level 3 Form R

Section F

Dissemination

F. Dissemination

1. Project information was disseminated to the community through the Community Communications Council. The Council consisted of leaders from business, the media, and education. The Council met eight times during the two year project.

2. It was recommended to the project teachers who had calculators and classroom materials that their students' parents be informed of the class's involvement with calculators before the project started. A sample letter was provided. The Parent Survey indicated that 77% of these parents knew about the project before it started.

3. Information for the local school district was directed to the Department of Public Information, Columbus Public Schools. Several articles appeared in the district's newsletter, Intercom, during the two year project. A press release was issued from the department during the pilot phase. Several newspaper articles and television spots resulted from this release.

   Due to the financial status of the Columbus Public Schools during the field test, a news release was not felt (by the public information specilaists) to be appropriate. Very little information was disseminated to the community through the media during the second year of the project.

4. The staff has received requests for project materials from various persons around the country due to an article published in the Calculator Information Center, Reference Bulletin No. 23, April, 1979. The article briefly stated the student instructional units which have been developed.

5. There was no effort made by the staff to disseminate the project materials. The project materials will be made available to the Department of Education, State of Ohio, after the performance results are analyzed and conclusions are drawn.

Section G

Conclusions/Recommendations

G. Conclusions/Recommendations

Conclusions

The student and teacher performance objectives and evaluation outcomes for the two years of the project are summarized in Tables 1, 2, and 3. Overall, two of the nine performance objectives of the two year projects were achieved. The two performance objectives which were achieved related to the training of pilot and field test teachers to use calculators and materials in classroom instruction. In addition, teachers rated the training workshops highly in terms of value to them in teaching mathematics.

None of the seven performance objectives for students were achieved. However, the criterion level of performance was reached on the tests of module achievement in two modules - Basic Facts and Properties. With the use of a calculator, students were able to perform at the criterion level on the Decimal Computations Test, but they could not reach the criterion level using paper and pencil.

Students exhibited approximately a three month gain in grade equivalent scores on the computations subtest of the Comprehensive Test of Basic Skills when they were permitted to use calculators rather than just paper and pencil. However, calculators made little difference in the grade equivalent of average scores on the arithmetic concepts and applications subtests.

Recommendations

The first two recommendations relate to follow-up studies of students and teachers who participated in the study. Little is known about the effects of the use of calculators upon the long range mathematics performance levels of students. As part of the testing program in the Columbus Public Schools, students are tested each year in grades four through eight with an appropriate level of the mathematics test that was used in this study. Assuming continuation of the same testing program, three to five years of longitudinal data will be collected on students who participated in the calculator and materials, calculator only, and control groups. Although many alternative hypotheses for any long range differences among the three groups might be formulated, the data would still represent a reasonable attempt to measure long term effects of the use of calculators.

The use of calculators in the classroom was a new experience for the majority of teachers participating in the study. Lessons learned and knowledge gained during the first year of calculator usage could affect instructional effectiveness in the second and subsequent years of calculator usage. Since some of the teachers have requested

Table 1

Summary of First Year
Student Objectives (1977-1978)

Objective	Results
After receiving 8 weeks of instruction involving a sample of the materials developed for the student instruction package from a trained teacher, 80 percent of the students in the pilot classes will demonstrate the ability to correctly solve 75 percent of selected problems relating to the objectives of the instruction as measured by a locally constructed test administered by the student's classroom teachers on or before May 31, 1978.	65 percent of the students solved 75 percent of the problems correctly on 7 module achievement tests. Objective was not achieved.
After receiving 8 weeks of instruction involving a sample of the materials developed for the student instructional package from a trained teacher, 80 percent of the students in the pilot classes will demonstrate an increased level of achievement in mathematics as measured by an appropriate level of the Comprehensive Test of Basic Skills administered on or before April 3, 1978, and on or before May 31, 1978, by the classroom teacher.	49 percent of the students demonstrated an increased level of achievement in mathematics. Objective was not achieved.

Table 1 (Continued)

Summary of First Year
Student Objectives (1977-1978

Objective	Results
After receiving 8 weeks of instruction involving a sample of the materials developed for the student instructional package from a trained teacher, 80 percent of the students in the pilot classes will demonstrate an improved attitude toward learning and using mathematics as measured by a scale to be selected, administered by the students' classroom teachers on or before April 3, 1978 and on or before May 31, 1978.	59 percent of the students demonstrated an improved attitude toward mathematics. Objective was not achieved.

Table 2

Summary of Second Year
Student Objectives (1978-1979)

Objective	Results
After receiving 26 weeks of instruction involving the student instructional packages from a trained teacher, 80 percent of the students will demonstrate the ability to correctly solve 75 percent of selected problems relating to the objectives of the instruction as measured by a locally constructed test administered by the students' classroom teacher on or before May 18, 1979.	65 percent of the students solved 75 percent or more of the problems correctly on 7 module achievement tests. Objective was not achieved.
After receiving 26 weeks of instruction involving the student instructional packages and a calculator from a trained teacher, 80 percent of the students will exhibit increased levels of achievement in mathematics as measured by appropriate levels of the CTBS administered on or before November 1, 1978, and on or before May 18, 1979, by the classroom teachers.	58.5 percent of the students demonstrated an increased level of achievement in mathematics. Objective was not achieved.

Table 2 (Continued)

Summary of Second Year
Student Objectives (1978-1979)

Objective	Results
After receiving 26 weeks of instruction involving the student instructional packages and a calculator from a trained teacher, 80 percent of the students will demonstrate an improved attitude toward learning and using mathematics as measured by the Attitude Towards Mathematics Scale administered by the students' classroom teachers on or before November 1, 1978, and on or before May 18, 1979.	39 percent of the students demonstrated an improved attitude toward mathematics. Objective was not achieved.
After receiving 26 weeks of instruction, mean scores of randomly selected classes receiving instruction involving the student instructional packages and calculators from trained trachers will be significantly higher ($p < .10$) on the posttest CTBS, posttest Attitude Towards Mathematics, and Test of Prediction and Computer Literacy than the means of randomly selected classes using only calculators and randomly selected control classes as determined by a multivariate analysis of covariance of the posttest class means using the pretest class means of the CTBS, Attitude Towards Mathematics, and Test of Prediction and Computer Literacy as covariates. The pretest will be administered on or before November 1, 1978 and the posttest will be administered on or before May 19, 1979.	No significant difference among the three treatment groups was observed on the CTBS, Attitude Towards Mathematics and the Test of Prediction and Computer Literacy Objective was not achieved.

Table 3

Summary of First and Second Year Teacher Objectives (1977-1978, 1978-1979)

Objectives	Results
First Year: 1977-1978	
After completing the teacher training package, 80 percent of the teachers selected for the pilot test of the student instructional package will be able to respond correctly to 80 percent of the items included in the posttest of the teacher training package administered on or before March 31, 1978.	100 percent of the teachers responded correctly to 80 percent or more of the items on the teacher training posttest. Objective was achieved.
Second Year: 1978-1979	
After completing the teacher training package, 90 percent of the teachers selected for the pilot test of the student instructional package will be able to respond correctly to 80 percent of the items included in the posttest of the teacher training package administered to the teachers on or before November 30, 1978.	91 percent of the teachers responded correctly to 80 percent or more of the items on the teacher training posttest. Objective was achieved.

the calculators for their classrooms for another year, both teacher reactions and student attitudes and performances could be assessed in these classrooms.

Both suggested follow-up studies could be conducted with little or no classroom intervention to collect data. If time constraints of the staff of the Columbus Public Schools do not permit completion of the follow-up studies, the studies would certainly be appropriate as thesis or dissertation topics.

The project staff in conjunction with the project consultants agreed that there are certain mathematical topics which are necessary for proper understanding by students before calculators can be utilized effectively. The topics in question were addressed in five of the eight student modules which were written. The modules were Place Value, Decimal Computation, Properties, Rounding, and Estimation. This material which covers the understanding of decimals, rounding and estimation skills has not traditionally been taught in grades 4, 5 and 6 to any degree of mastery. Since the field test was for one year, these introductory, fundamental topics had to be presented to students at all three grade levels participating in the project. If the calculator program could have been implemented over a three year period, it would not have been necessary to present all of the designed calculator modules at each grade level in one year. For example, if one effect of the total program was to show improved skills in solving application problems, a fourth grade student could learn the fundamental skills of using a calculator and then as a fifth or sixth grade student concentrate on the use of the calculator with application problems. The total program of eight calculator modules could be presented to students over a three year period and still permit an effective treatment.

Many questions have been raised concerning whether or not elementary children can understand the mathematical concepts involved with using a calculator effectively. Two questions are foremost in discussion: "Can elementary students understand decimal numbers?" and "Will elementary students accept incorrect answers on calculators as being correct just because they were produced by little magic boxes?" The four student instructional units which address themselves specifically to these questions are Place Value, Decimal Computation, Rounding and Estimation. Compared to fifth and sixth graders, it can be observed that fourth graders were especially low in their module posttest scores in Decimal Computation without calculators and in Estimation. It is recommended that educators who are considering implementation of this program be made aware of this concern at the fourth grade level. However, low achievement scores on these two units by fourth graders seem to reflect their lack of experience with these concepts.

It is easier for teachers to incorporate new concepts and materials into curriculum after they have experienced the materials in their classroom over a period of time. From observations in classrooms, it became evident that most teachers were instructing with calculators and the materials completely separate from their regular math curriculum. Since the teachers were learning and exploring new techniques in which calculators help in the teaching of mathematics, they were reluctant to incorporate these new experiences into their regular math program during the field test. Now that the project teachers have had calculator experiences and have formed their own professional opinions about calculators, they are better prepared to use calculators advantageously in the instruction of mathematics. It is recommended that future sessions be conducted with these experienced teachers to encourage continual growth in the coordination of teaching mathematics with calculators.

Section H

Project Phase-In

H. Project Phase-In

1. Continuation Efforts

Upon completion of ESEA Title IV-C funding, the Columbus Public Schools will offer the calculator program to teachers in the public and non-public schools in Columbus. The calculators from the two year research project will be available to classroom teachers. The program classroom materials will be printed by the Columbus Public Schools, Division of Instruction under the direction of Mr. Earl Tharp, Supervisor, Mathematics. This effort will enable the major activities of the project to continue.

2. Phases To Be Discontinued

Due to a lack of funds, the Columbus Public Schools will not be able to support the training of teachers for the calculator program. The Ohio State University, Department of Mathematics, has shown some interest and willingness to conduct teacher training courses for the calculator program.

3. Equipment Inventory

There was no item purchased during the two year project which cost over $300.

Section I

Project Instructional Materials

I. Project Instructional Materials

The main products of the two year project are the Teacher Reference Manual and the student instructional units: Basic Facts; Place Value; Decimal Computations; Properties; Rounding; Estimation and Applications. These publications are found under separate covers with this report.

Documentation on how the twenty hours of teacher training was conducted is also available with this report.